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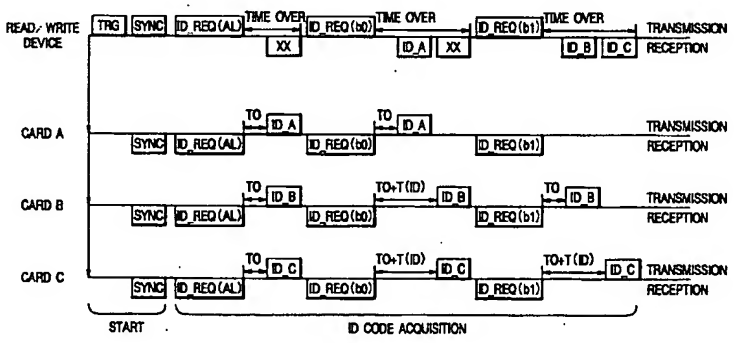
(54) Contactless IC card system and communication method thereof

(57) Even when a plurality of cards have entered an communication area, the cards within the communication area may be accessible, and, if a data collision occurs, the order of accessing to the cards is expeditiously determined to perform an efficient communication. Each card determines a timing for returning a response block containing an ID code based on conditions directed by a read/write device and the ID code of its own. The read/write device is caused to receive the response block returned by the contactless IC card and to detect a data collision. Based on this result, the conditions are changed so that a respective response block containing an ID code is returned again, thereby concurrently processing the plurality of contactless IC cards.

FIG. 1



XX : DATA COLLISION

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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a contactless IC card system for performing data communication by means of an electromagnetic wave and, more particularly, relates to such system and communication method in which communication may be normally performed even when a plurality of contactless IC cards concurrently enter into the range capable of communication with a reader/writer.

DESCRIPTION OF THE RELATED ART

Contactless IC cards are to perform data communication at a position physically separated from an associated reader/writer and are used for example in factory automation, transport system, control over physical access to a room, behavioral investigation, etc. Such contactless IC card possesses write-in, read-out and data processing functions.

Fig.11 is a block diagram schematically showing the construction of a contactless IC card system of the type to which the present invention may be applied. In this figure, a contactless IC card system 100 includes a contactless IC card (hereinafter referred to simply as a card) 10 and a read/write device (hereinafter referred to as W/R) 20. The contactless IC card system 100 is usually constituted by one R/W 20 and a plurality of cards 10.

The card 10 includes: an antenna 1 for performing receiving/transmitting of data from/to the R/W 20 by means of electromagnetic wave as indicated by "E"; a receiving circuit 2a for demodulating a signal received at the antenna 1; a transmitting circuit 2b for modulating a signal to be transmitted and driving the antenna 1 to perform its transmission; and an I/O control circuit 3 for effecting a serial/parallel conversion of the transmitting signal and reception signal.

It further includes: CPU 4 for performing writing/reading of data (including transmitting/receiving of data) as well as various data processing; ROM 5 for storing a control program 5a or the like to operate the CPU 4 in a manner as described; RAM 6 for storing for example the result of processing; and a bus 7 for interconnecting the CPU 4, ROM 5, RAM 6 and I/O control circuit 3.

An oscillating element 8 generates an internal clock for the card 10 and a battery 9 provides a power supply. What is denoted by "T" is a trigger signal line for turning the card 10 from its sleep state to operating state by directly supplying a received trigger signal to the CPU 4 from the receiving circuit 2a.

The R/W 20 fundamentally has a similar structure as the card 10. The R/W 20 includes: an antenna 21 for performing transmitting/receiving of data to/from the card 10 by means of electromagnetic wave "E"; a receiving circuit 22a for demodulating a signal received at the antenna 21; a transmitting circuit 22b for modulating a signal to be transmitted and transmitting it by driving the antenna 21; and an I/O control circuit 23 for effecting a serial/parallel conversion of the transmitting signal and reception signal.

It further includes: CPU 24 for performing writing/reading of data (including transmitting/receiving of data) as well as various data processing; ROM 25 for storing a control program 25a or the like to operate the CPU 24 in a manner as described; a volatile RAM 26 for temporarily storing data; a nonvolatile EEPROM 27 for temporarily storing the result of processing; and a bus 28 for interconnecting the CPU 24, ROM 25, RAM 26, EEPROM 27 and I/O control circuit 23. It should be noted that power supply and the portion for generating a clock for the R/W 20 are not shown. A broken line as indicated in Fig.11 will be described later.

In such contactless IC card system, since data communication may be performed from/to a physically separated position, there may be the event of a plurality of cards entering into an area where communication to/from the R/W 20 is possible. In such a case, an interference occurs and normal communication cannot be performed. As means for eliminating such disadvantage, the following systems (referred to as ANTI-COLLISION) have been proposed.

In Japanese Patent Publication No. 3-2271 (Prior-Art Example 1), the interval of response signal (identification code) consecutively (repeatedly) output from the card is varied in a pseudo-random manner, so that it will not be overlapped by response signal from another card. An occurrence of interference is judged from the fact as to whether a predetermined code is included in received data. The card varies the code interval by transmitting identification code to a time slot which is selected from a predetermined number of time slots (fixed length of time period during which an identification code may be transmitted) in a pseudo-random manner.

In Japanese Patent Publication No.6-1512 (Prior-Art Example 2), the output timing of response signal of the card is delayed in accordance with the content of a response order memory so that the response signal will not be overlapped by another. The content of the response order memory is different from one card to another.

In Japanese Patent Publication No. 4-49078 (Prior-Art Example 3), an inherent (fixed) response delay time is provided for each of the cards to avoid an overlapping of response signals.

Japanese Patent Laid-Open No.2-226392 (Prior-Art Example 4) employs a system in which the outgoing level of power is gradually lowered to narrow the area capable of communication to recognize a particular card.

In Japanese Patent Laid-Open No.2-226390 (Prior-Art Example 5), each card is caused to transmit its ID code respectively at the time of entering and exiting the communication range to reduce probability of ID codes being simultaneously output.

In Japanese Patent Laid-Open No.2-148282 (Prior-Art Example 6), a response signal returned at a timing after elapse of a predetermined time period from a point in time of the providing of a periodic signal is detected as a read information. Specifically, reflection of an electromagnetic wave is utilized.

In Japanese Patent Laid-Open No.5-159114 (Prior-Art Example 7), temporary IDs are given respectively to a plurality of cards entering into the communication area in their order of entrance so as to process the plurality of cards within the communication area.

The conventional contactless IC card systems constructed as described have respective problems as follows.

First, in Prior-Art Example 1, since a predetermined time slot number and receiving mode is set for the read/write device even when only one card has entered into the communication area, a longer processing time results as a next inquiry signal cannot be transmitted. Further, when a large number of cards exist within the communication area, it is necessary to provide a larger number of time slots, resulting in a further increase in the processing time.

Similarly, in Prior-Art Example 4, if a large communication area is set on the assumption that a large number of cards exist within the communication area, the processing speed becomes slower.

The PRIOR-ART EXAMPLES 2 and 3 are not practical if a large number of cards are to be used in one system. If an inherent delay time different from another is provided to all the cards, a delay time can be enormous. Further, if a group of cards are provided with a common delay time, reading of data is impossible when cards of the same group have entered into the communication area.

Further, in PRIOR-ART EXAMPLES 5 and 7, processing is impossible in the case of simultaneous entering into (simultaneous exiting from) the communication area. Here, the word "simultaneous" refers to an occurrence within a time period which is required for transmission of an ID code. Furthermore, in PRIOR-ART EXAMPLE 6, only the cards located within a predetermined distance range from the R/W can be processed.

SUMMARY OF THE INVENTION

To eliminate the above described problems, it is an object of the present invention to provide a contact less IC card system and communication method thereof in which: even when a plurality of cards have entered into a communication area, the cards within the communication area may be accessible; even if a collision of data occurs, the order of accessing is expeditiously determined to access again in accordance with such order; and it is possible to perform an efficient communication where the processing time as a whole may be shortened.

In view of the above objects, a contactless IC card system including contactless IC cards and a read/write device to perform communication by means of an electromagnetic wave is provided in accordance with a first aspect of the invention, including ID code acquisition means for reading the ID codes of the contactless IC cards by the read/write device and data communication means for identifying contactless IC cards for communication based on the obtained ID codes to cause respective commands to be executed. The ID code acquisition means determines each timing at which the respective contactless IC card returns a response block containing an ID code based on the conditions directed to the respective card from the read/write device and the own ID code. It causes the read/write device to receive the response block returned by the contactless IC card and to detect a data collision. Based on this result, the read/write device is caused to request returning of a response block containing ID code with conditions being changed to concurrently process a plurality of contactless IC cards.

In a second aspect of the invention, the ID code acquisition means of the contactless IC card system according to the first aspect concurrently executes ID code acquisition and data communication for executing respective commands with contactless IC cards for communication being identified based on obtained ID codes by means of one command block transmitted by the read/write device.

In a third aspect of the invention, the contactless IC card system according to the first aspect further includes counting means for counting contactless IC cards entering into the communication area within a predetermined time period, and the ID code acquisition means determines number of returning timings for a response block containing an ID code based on a count result of the counting means.

In a fourth aspect of the invention, a communication method of contactless IC card system including contactless IC cards and a read/write device for performing communication by means of an electromagnetic wave is provided, including the steps of: ID code acquisition for reading the ID codes of the contactless IC cards by the read/write device; and data communication for identifying contactless IC cards for communication based on the obtained ID codes to cause respective commands to be executed. In the ID code acquisition step, the respective timing at which each contactless IC card returns a response block containing an ID code is determined based on the conditions directed to the respective card from the read/write device and the ID code of its own. It causes the read/write device to receive the response block returned by the contactless IC card and to detect a data collision. Based on this result, the read/write device is caused to request returning of a response block containing ID code again with conditions being changed so as to concurrently process a plurality of contactless IC cards.

In a fifth aspect of the invention, in the ID code acquisition step of the communication method of contactless IC card system according to the fourth aspect, ID code acquisition and data communication for executing

respective commands with contactless IC cards for communication being identified based on obtained ID codes are concurrently executed by means of one command block transmitted by the read/write device.

In a sixth aspect of the invention, the communication method of contactless IC card system according to the fourth aspect further includes a counting step for counting contactless IC cards entering into the communication area within a predetermined time period, and number of returning timings for a response block containing an ID code is determined in the ID code acquisition step based on a count result of the counting step.

The system according to the first aspect of the invention includes: ID code acquisition means for reading the ID codes of the contactless IC cards by the read/write device and data communication means for identifying contactless IC cards for communication based on the obtained ID codes to cause respective commands to be executed. Each timing at which the respective contactless IC card returns a response block containing an ID code is determined by the ID code acquisition means based on the conditions directed to the respective card from the read/write device and the ID code of its own. It causes the read/write device to receive the response block returned by the contactless IC card and to detect a data collision. Based on this result, the read/write device is caused to request returning of a response block containing ID code with conditions being changed to concurrently process a plurality of contactless IC cards.

In the system according to the second aspect of the invention, the ID code acquisition means concurrently executes ID code acquisition and data communication for executing respective commands with contactless IC cards for communication being identified based on obtained ID codes by means of one command block transmitted by the read/write device.

The system according to the third aspect of the invention further includes counting means for counting contactless IC cards entering into the communication area within a predetermined time period. The ID code acquisition means determines number of returning timings for a response block containing an ID code based on a count result of the counting means.

The communication method according to the fourth aspect of the invention includes the steps of: ID code acquisition for reading the ID codes of the contactless IC cards by the read/write device; and data communication for identifying contactless IC cards for communication based on the obtained ID codes to cause respective commands to be executed. In the ID code acquisition step, the respective timing at which each contactless IC card returns a response block containing an ID code is determined based on the conditions directed to the respective card from the read/write device and the ID code of its own. It causes the read/write device to receive the response block returned by the contactless IC card and to detect a data collision. Based on this result, the read/write device is caused to request returning of a response block containing ID code again with conditions being changed so as to concurrently process a plurality of contactless IC cards.

In the ID code acquisition step of the communication method according to the fifth aspect of the invention, ID code acquisition and data communication for executing respective commands with contactless IC cards for communication being identified based on obtained ID codes are concurrently executed by means of one command block transmitted by the read/write device.

The communication method according to the sixth aspect of the invention further includes a counting step for counting contactless IC cards entering into the communication area within a predetermined time period. Number of returning timings for response block containing an ID code is determined in the ID code acquisition step based on a count result of the counting step.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 shows starting of communication sequence and ID code acquisition process according to a first embodiment of the invention.

Fig.2 shows data communication process of communication sequence according to the first embodiment of the invention.

Figs.3A to 3C each shows a command block in the first embodiment of the invention.

Fig.4 shows a response block in the first embodiment of the invention.

Fig.5 shows a processing flow of the ID code acquisition process according to the first embodiment of the invention.

Fig.6 shows starting of communication sequence, ID code acquisition and "data communication + ID acquisition" process according to a second aspect of the invention.

Fig.7 shows data communication process of communication sequence according to the second embodiment of the invention.

Fig.8 shows a command block in the second embodiment of the invention.

Fig.9 shows disposition of read/write device of the system according to a third embodiment of the invention.

Fig.10 shows a communication sequence according to the third embodiment of the invention.

Fig.11 shows the construction of a contactless IC card system to which the present invention may be applied.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described in accordance with the accompanying drawings.

The construction of a contactless IC card system according to the invention is fundamentally identical to that shown in Fig.11 except that the contents of control program 5b stored in the ROM 5 of the card 10 and control program 25b stored in the ROM 25 of the R/W 20 are

different from the conventional programs 5a, 25a, respectively. Accordingly, Fig.11 will be regarded as showing the construction of contactless IC card system according to the invention.

It should be noted that the ID code acquisition means and data communication means in the first to third aspects of the invention are constituted by the hardware as shown in Fig.11 and the above described control programs 5b, 25b.

The card 10 incorporates the CPU 4, serving as a microcomputer, and the battery 9. When not in communication with the R/W 20, the card 10 is usually in its sleep state to reduce consumption of the battery 9. It is started to perform communication upon a reception of a trigger signal which is transmitted from the R/W 20.

First, fundamental operation of the card 10 of Fig.11 will be briefly described. Communication by means of an electromagnetic wave E between the card 10 and the R/W 20 is performed in the manner of a serial transmission. The electromagnetic wave E received at the antenna 1 is amplified and demodulated at the receiving circuit 2a and is input to the I/O control circuit 3 as a digital signal. It is converted into a parallel data at the I/O control circuit 3. A trigger signal T from the receiving circuit 2a serves as the signal for starting the CPU 4.

The CPU 4 operates according to the control program 5b stored in the ROM 5. In accordance with commands and data input from the I/O control circuit 3 through the bus 7, it executes writing/reading to/from the RAM 6 and processing such as transmission of a response. In the case of transmitting operation, the CPU 4 inputs a transmitting data to the I/O control circuit 3 through the bus 7. The transmitting data in the form of a parallel data is converted into a serial data by the I/O control circuit 3 and is output to the transmitting circuit 2b. The transmitting circuit 2b effects modulation in accordance with such data and transmits electromagnetic wave E by driving the antenna 1.

In the following embodiments, it is assumed that the system of the present invention is applied to controlling over the history of entering/exiting a room, or to a dynamic investigation on persons or articles, i.e., provided are the system and communication method suitable for identifying a plurality of persons (articles) each possessing a card 10 who approach a single R/W 20 in an unspecified order.

EMBODIMENT 1

In a first embodiment of the invention, a peculiar code (hereinafter referred to as ID code) is given to each card. This is usually stored to a memory within each card when issuing the card. Timing at which a response is to be returned is directed from the R/W by using such ID code to avoid a collision of data.

The communication method according to the first embodiment includes an ID code acquisition step for acquiring ID codes of all the cards within a communication area and a data communication step for performing communication by means of time-division using the obtained ID codes.

In the ID code acquisition step, if a collision of ID codes occurs, the R/W resends to the cards a conditional ID code request command for directing timings at which the ID codes are to be returned. Each card determines the time period from the completion of receiving of the command to providing of the ID code based on the conditions designated by the R/W.

A method of communication of the invention will now be described with reference to Figs.1 and 2. In this example, a case is assumed of three cards A, B, C existing within the communication area. An 8-bit ID code is provided for each card and the codes are represented as 00_{16}, 01_{16}, 03_{16} by hexadecimal notation, respectively.

(Starting)

(1) As shown in Fig.1, the R/W (read/write device) provides a trigger signal TRG to start the cards. For example, the TRG may be a carrier which is not modulated. Following the TRG, a code SYNC for indicating a start of communication process is transmitted.
(2) After started by TRG and receiving SYNC, a command processing is started (processing of a command is enabled).

Here, if SYNC is provided with a code for indicating a point in time of communication to discriminate each communication from another, it is advantageous in avoiding an overlap processing of a card. Having received SYNC, the card compares it with the last communication point in time of its own, and, only if a predetermined time period has been elapsed, receiving of the command is continued. Processing of the cards without an elapse of such time period is already complete in the last communication.

Further, since a card entering into the communication area during a communication process does not receive SYNC, no command processing is performed and a response is not returned. For this reason, no disorder occurs in the ID code acquisition process (step) to be described later and the card which has previously entered into the communication area may be processed with a priority.

(Acquisition of ID codes)

(3) The R/W provides an ID code request command ID_ REQ(AL). The ID_REQ(AL) is a command block requesting all the cards to return a respective ID code. This command block will be described later in detail.
(4) After receiving and decoding such command block, all the cards promptly return response blocks containing ID code, respectively. These response blocks (ID_A ~ ID_C) are provided after a time period T0 from the completion of reception of the

command block ID_REQ(AL). The response blocks will be described later.

(5) The R/W detects an occurrence of data collision by checking the parity, occurrence of a framing error, error check code ECC, etc. If an error occurs, it transmits ID_ REQ(b0) which is a conditional ID code request command with regarding all the cards as the candidates for processing. The ID_REQ(b0) is a command for shifting the output timing of the response block by checking the least significant bit [LSB(0 bit)] of the ID code.

Here, if no data is received in a predetermined time period, it is regarded as a "time over" and the R/W starts executing again from providing of TRG. If only one card exists in the communication area, since no collision of ID codes occurs, the system proceeds to data communication as shown in Fig.2.

(6) Each card checks the least significant bit of the ID code. It returns ID code promptly if LSB is "0" or after waiting one response block length T(ID) of the ID code if "1". At this time, time from completion of reception of the command block to providing of the response block containing an ID code is T0 (T0 being command processing time of the card) if LSB is "0" or is T0+T(ID) if LSB is "1". It is T0 for the card A and T0+T(ID) for the cards B and C.

(7) The R/W receives two response blocks and checks an error thereof. ID code of the response block without an error is stored. In order to separate the response block with an error (causing data collision as indicated by XX in Fig.1), ID_REQ(b1) is transmitted so that it is executed by the cards having "1" for LSB of ID code. (This may be described using an example of command block shown in Fig.3A to be described later as "STCR LEN ID_REQ b1 (???????0) 0 ECC".)

(8) Since the card A is not a candidate for executing the command, it does not return a response. The cards B, C check the bit at the second lowest order digit. Since, in this case, offset time is "0" (portion of T0F1 of Fig.3A), they return a response at timings T0, T0+T(ID), respectively.

(9) The R/W receives the responses and checks for an error. If all the blocks are free from an error, the ID code acquisition process (step) is complete after storing the obtained ID codes and the system proceeds to data communication process (step) as shown in Fig. 2.

(Data communication)

(10) The R/W transmits a command block COMMAND which is obtained by adding ID codes to a command and receives responses from the cards. Examples A, B of command block are described below. Example A is a format for requesting individual processing by each card where a plurality of sets of command and ID code exist within the block. Example B is a format for causing all the cards to execute the same command.

(11) Each card receives and interprets the COMMAND block. It executes those commands to which its ID is added and transmits a response after waiting a directed time period.

(12) The R/W receives and processes responses from the respective cards in a time-divisional manner and transmits a termination command END(AL).

(13) Each card receives the termination command and returns to its sleep mode.

Examples of character format for a command block are shown in Figs.3A to 3C. STCR is a code for indicating start of a command block transmitted by the R/W and LEN indicates a block length. ECC is an error check code for the block [check sum, CRC (cyclic redundancy code), etc.].

The ID_REQ(bn) block of Fig.3A will now be described. ID_REQ is a command code for requesting returning of ID code, "bn" being a code for indicating a bit position (bit n:n=0, 1, 2, 3) to be checked. CND is a code for indicating the cards which are the candidates for executing the command, i.e., the code indicates, for example, a card group having a value of "0" for LSB of ID code.

CND and TOF form a pair, where TOF is the offset time when the cards of a group specified by CND are to provide response block. Each card of the group indicated by CND checks the "bn" bit and returns a response at a timing of T0+TOF or T(ID)+TOF. If candidate cards for executing the command are not specified, the codes of CND and thereafter are not required. Further, in the case of ID_REQ(AL), the codes that follow "bn" are not required. However, ECC is required.

The COMMAND blocks A, B of Figs.3B and 3C will now be described. The command block A contains sets each including: a command COM; ID code ID_X for indicating candidate card for executing the command; TW for designating delay time (waiting time) for transmission of a response; and PAR, parameter necessary for executing the command, for example, which is an address and write data in the case of a write command. The number of such sets corresponds to the acquired ID codes. Each card receives the command block and executes a command corresponding to its ID code. It transmits a response after a waiting time designated by TW.

The COMMAND block A is used when requesting a different processing for each card. Since, usually, execution of processing common to the cards is more likely, the COMMAND block B is more effective in such a case. The block B contains: a command code COM; ID code ID_ of the card to be processed; PAR necessary for executing the command; and TW indicating a waiting time. In the case of a common command, since the response length is constant, one TW suffices (i.e., TW may be a transmitting time period for a response). Each card receives such command block and executes the common command. Thereafter, it transmits a response after

waiting an integer-multiple of the time period designated by TW corresponding to the order of its ID code. In this example, as shown in Fig.2, such waiting time is TW×0 for card A, TW×1 for card B and TW×2 for card C.

An example of character format for a response is shown in Fig.4. STCC is the code for indicating start of a response block transmitted by R/W, and LEN and ECC are identical as those in a command block. A response block contains a respective ID code ID_X and the result of processing of the command RESP. In the case of a response to an ID requesting command, RESP is not required.

Algorithm of the ID code acquisition process will now be described with reference to Fig.5. Fundamentally, if a data collision occurs, conditions are added so as to separate it into two different timings. In other words, the R/W transmits an ID code request command so that the bit at a more higher order position is checked and the output timing is changed into two types depending on whether such bit is "1" or "0". Two type of timings are provided because it is the smallest number necessary for separating a collision.

In Fig.5, an 8-bit ID code is assumed and is represented for example as ????0100. Here, a "?" is undefined and may be either "1" or "0". The block with (????0100) means that all the cards corresponding to this ID code return a response at the timing where the block is located. "T0,T0+T(ID) · · · (T0 being T0+T(ID))" is the time period to providing of an ID code after completion of reception of the ID code request command. An "XX" represents a data collision and ID_X represents an ID code normally received by the R/W or the state of no reception data. Further, command blocks for obtaining the responses of STEPS 1 to 6 are shown in accordance with the above described character format examples.

Upon transmitting of the command block ID_REQ(AL) by the R/W at STEP 1, all the cards within the communication area return ID codes at timing T0. At this time, if a data collision occurs, existence of a plurality of cards is presumed. At STEP 2, the R/W transmits ID_REQ(b0) to separate it into two elements and receives responses.

Here, if data collision occurs at timings of both T0 and T0+T(ID), cards of ID code (???????0) and of ID code (???????1) exist both in a plural number. At STEP 3, in order to separate this, the R/W transmits ID_REQ(b1) respectively to the cards of (???????0) and (???????1). As a result, responses are returned of the cards corresponding to (??????00) and (??????10) respectively at timings of T0 and T0+T(ID) and of the cards corresponding to (??????01) and (??????11) respectively at timings of T0+T(ID)×2 and T0+T(ID)×3. If, as a result, ID_X1 is normally received, this is stored. For the conditions resulting in an occurrence of data collision, branching of the conditions further proceeds in a manner similar to the above. In this way, branching of the conditions is repeated until all the data collisions are eliminated.

In the above described embodiment, the R/W in the ID code acquisition process is able to decompose data collisions by suitably adding conditions based on the responses from the cards.

Also, in processing a card, the R/W will not wastefully wait for a reception of data for a lengthy time period. Further, it is able to promptly transit to providing of next trigger even when no card exists within the communication area.

Since the system does not depends on any contingency such as an individual delay for each card or random numbers in avoiding a collision, it is possible to positively identify the ID codes and an average processing time per card may be shortened even when a large number of cards are to be concurrently processed.

It should be noted that, in the above embodiment, the conditional expression for designating output timing of the ID code is to indicate bit position in an ID code and timing is determined based on whether the bit is "1" or "0". However, it is also possible, for example, to designate a certain value as a conditional expression so that timing is determined based on whether the ID code is larger or smaller than such designated value.

While, in the above embodiment, two types of conditional branches are provided when a data collision occurs, 4 types, 8 types · · · may be provided by setting the number of bits to be checked to 2 bits, 3 bits · · · .

Further, while, in the above embodiment, the check bit for branching the conditions is shifted sequentially from a lower order position to upper order position, it may be shifted in a skipping manner. Especially, such as when a coincidence is confirmed of a plurality of cards by data collision, separation may be expedited by skipping that particular bit. For example, if no electromagnetic wave is to be emitted for a transmission data "1" in ASK (amplitude shift keying) modulation, bits for which received collision data are data "1" may be almost always skipped.

EMBODIMENT 2

A second embodiment of the present invention is a modification of the first embodiment, where a transition to data communication is effected as soon as at least one ID code is obtained in the ID code acquisition process and, at the same time, the ID code acquisition is further continued so that data communication is sequentially performed upon an acquisition of respective ID code. In this case, because data is sequentially processed in the order of acquisition of ID codes, earlier results may be obtained for those with shorter processing time. Since processing may be efficiently performed (processing speed appears to be higher), it is especially effective to those applications where result of processing is displayed to be seen by the user.

After normally receiving at least one ID code in the ID code acquisition process, while data communication is executed by a command to which the ID code is

imparted, a conditional ID code request command is added to this command string when an error due to data collision is furthermore detected. Thereby, returning of ID code is directed at a different timing from the response made by the previous data communication.

Operation of this embodiment will now be described using Figs.6 to 8. Sequence of starting and ID code acquisition process is identical to the foregoing embodiment.

When at least one ID code is obtained in the ID code acquisition process, the R/W transmits a command block "ID_ REQ(b1)+COM(ID_A)" by adding a data communication command to an ID code request command, so as to concurrently perform acquisition of ID code and data communication. An example of such composite command block is shown in Fig.8. This is formed as combining the command blocks of Figs.3A and 3B. The command string in this case is "STCR LEN ID_REQ b1 (???????1) 0 COM ID_A T(ID)x2 PAR ECC".

Each card executes a command directed thereto and returns response at a designated timing. The R/W receives this and transmits a command block which combines:

data communication command when a new ID code has been obtained;

termination command for the card with processing having been completed when a data communication has been complete; and

ID code request command with further branched conditions when an error has been detected in a response block of ID code.

This is repeated until processing of all the cards is complete.

In this embodiment, earlier results may be obtained for those with shorter processing time and processing may be efficiently performed (processing speed appears to be higher). It is thus especially effective to those applications where a gate is to be opened based on the result of a data communication or where read out data is displayed to be seen by the user. Further, since data communication is effected immediately upon an acquisition of ID code, probability of the relevant card having left the communication area is small.

EMBODIMENT 3

In the ID code acquisition process of the first and second embodiments of the invention, a method is employed in which the ID code returning timing is started as a single timing and then it is sequentially branched into two elements. For this reason, if a large number of cards have simultaneously entered into the communication area, time is required for the convergence of ID code acquisition process. A method for mitigating this is shown in a third embodiment of the invention. Specifically, in the third embodiment, an assumption is made that the communication area is relatively large and that a large number of cards must be concurrently processed. A processing method suitable for such case will be described below.

The construction of a contactless IC card system according to the third embodiment is shown in Fig.9. The R/W 20 is provided with means for counting number of objects that enter a communication area 60. In this example, it is constituted by pairs each including an infrared-emitting device 50 and detector 51. The detector 51 counts the number of passing objects based on cutoff of the infrared ray from the infrared emitting device 50. The count value is counted up from an outputting of SYNC of the R/W 20 to the next outputting of SYNC and is read and reset by the R/W at the time of the outputting of SYNC through the line indicated by the broken line in Fig.11. Also, such counting of the number of passing objects may be performed at the CPU 24 by constituting a timer by means of a program at the R/W 20.

The communication sequence of this embodiment is shown in Fig.10. Cards A ~ C are identical to those of the first embodiment. After transmitting TRG, SYNC, the R/W provides an ID code request command. At this time, if the read count value is 3, the ID code request command is provided as ID_REQ(b1b0). The ID_REQ(b1b0) checks the bits of second low order digit (bit 1) and LSB (bit 0) and sets response returning timings to four types T0, T0+T(ID), T0+T(ID)x2, T0+T(ID)x3 corresponding to the combinations (0,0), (0,1), (1,0), (1,1) of (b1,b0). In other words, the command is defined so that the number of response returning timings is equal to or more than the count value. For example, if the count value is 5 to 8, the command is defined as ID_REQ(b2b1b0) so that eight different timings are provided.

In the example of Fig.10, the R/W transmits ID_ REQ(b1b0) addressing all the cards. The cards A to C return responses at the timings of T0, T0+T(ID), T0+T(ID)x3, respectively. In this case, since no data collision occurs, the R/W normally receives the ID codes and transition to data communication process is made.

Here, if a data collision occurs, the method of the first embodiment may be used to sequentially branch the conditions into two elements. Further, since the number of remaining cards may be seen by subtracting the number of obtained ID codes from the count value, it is even more efficient to define the command in such a manner that the number of response timings is always equal to or more than the number of remaining cards.

In this embodiment, convergence of the ID code acquisition process is greatly expedited.

In accordance with the first aspect of the invention as described, timing at which each contactless IC card returns a response block containing an ID code is determined by the ID code acquisition means based on the conditions directed by the read/write device and the ID code of the card. The read/write device is caused to receive response blocks returned by the contactless IC cards and to detect a data collision. Based on this result, the conditions are changed so as to request returning of a response block containing ID code again. Thereby, the read/write device directs the response returning timing

based on ID code peculiar to each card. Since each card is completely identified and there is no wasteful waiting time, an advantage is achieved that it is possible to provide a contactless IC card system in which an average processing time per card is shorter and an efficient communication is performed.

In accordance with the second aspect of the invention, an ID code acquisition and data communication for executing a command by identifying a contactless IC card for communication from obtained ID code are concurrently executed by means of one command block transmitted by the read/write device. Earlier results may be obtained for those with shorter processing time and processing may be efficiently performed (processing speed appears to be higher). An advantage is thus achieved that it is possible to provide a contactless IC card system which is especially effective to those applications where a gate is to be opened based on the result of a data communication or where read out data is displayed to be seen by the user.

In accordance with the third aspect of the invention, contactless IC cards entering into the communication area within a predetermined time period are counted. Number of returning timings for response block containing an ID code is determined based on the count result of such counting means. An advantage is thus achieved that it is possible to provide a contactless IC card system in which convergence (completion) of ID code acquisition is greatly expedited and communication is performed with a higher efficiency.

In accordance with the fourth aspect of the invention, similarly to the first aspect, in the ID code acquisition step, timing at which a response block containing an ID code is returned is determined by each contactless IC card based on the conditions directed by the read/write device and its own ID code. The read/write device is caused to receive response blocks returned by the contactless IC cards and to detect a data collision. Based on this result, the conditions are changed so as to request returning of a response block containing ID code again. Thereby, the read/write device directs the response returning timing based on ID code peculiar to each card. Since each card is completely identified and there is no wasteful waiting time, an advantage is achieved that it is possible to provide a communication method of contactless IC card system in which an average processing time per card is shorter and an efficient communication is performed.

In accordance with the fifth aspect of the invention, similarly to the second aspect, an ID code acquisition and data communication for executing a command by identifying a contactless IC card for communication from the obtained ID code are concurrently executed by means of one command block transmitted by the read/write device. Earlier results may be obtained for those with shorter processing time and processing may be efficiently performed (processing speed appears to be higher). An advantage is thus achieved that it is possible to provide a communication method of contactless IC card system which is especially effective to those applications where a gate is to be opened based on the result of a data communication or where read out data is displayed to be seen by the user.

In accordance with the sixth aspect of the invention, similarly to the third aspect, contactless IC cards entering into the communication area within a predetermined time period are counted. Number of returning timings for response block containing an ID code is determined based on the count result of such counting means. An advantage is thus achieved that it is possible to provide a communication method of contactless IC card system in which convergence (completion) of ID code acquisition is greatly expedited and communication is performed with a higher efficiency.

Even when a plurality of cards have entered an communication area, the cards within the communication area may be accessible, and, if a data collision occurs, the order of accessing to the cards is expeditiously determined to perform an efficient communication. Each card determines a timing for returning a response block containing an ID code based on conditions directed by a read/write device and the ID code of its own. The read/write device is caused to receive the response block returned by the contactless IC card and to detect a data collision. Based on this result, the conditions are changed so that a respective response block containing an ID code is returned again, thereby concurrently processing the plurality of contactless IC cards.

Claims

1. A contactless IC card system including contactless IC cards and a read/write device to perform communication by means of an electromagnetic wave, said contactless IC card system comprising:

   ID code acquisition means for reading ID codes of said contactless IC cards by said read/write device; and

   data communication means for identifying contactless IC cards for communication based on the obtained ID codes to cause respective commands to be executed;

   wherein said ID code acquisition means determining each timing at which the respective contactless IC card returns a response block containing an ID code based on conditions directed to the respective card from the read/write device and the own ID code; and the read/write device receiving the response block returned by the contactless IC card and detecting a data collision and, based on this result, requesting returning of a response block containing ID code again with conditions being changed to concurrently process a plurality of contactless IC cards.

2. The contactless IC card system according to claim 1 wherein said ID code acquisition means concurrently executes ID code acquisition and data com-

munication for executing respective commands with contactless IC cards for communication being identified based on obtained ID codes by means of one command block transmitted by said read/write device.

3. The contactless IC card system according to claim 1, further comprising counting means for counting contactless IC cards entering into the communication area within a predetermined time period, and wherein said ID code acquisition means determines number of returning timings for response block containing an ID code based on count result of the counting means.

4. A communication method of contactless IC card system including contactless IC cards and a read/write device for performing communication by means of an electromagnetic wave, said communication method of contactless IC card system comprising the steps of:

acquiring ID code by reading the ID codes of the contactless IC cards by the read/write device; and

communicating data by identifying contactless IC cards for communication based on the obtained ID codes to cause respective commands to be executed;

wherein each timing at which the respective contactless IC card returns a response block containing an ID code is determined in said step of acquiring ID code based on conditions directed to the respective card from the read/write device and its own ID code; the read/write device receiving the response block returned by the contactless IC card and detecting a data collision and, based on this result, requesting returning of a response block containing ID code again with conditions being changed to concurrently process a plurality of contactless IC cards.

5. The communication method of contactless IC card system according to claim 4 wherein, in said step of acquiring ID code, ID code acquisition and data communication for executing respective commands with contactless IC cards for communication being identified based on obtained ID codes are concurrently executed by means of one command block transmitted by said read/write device.

6. The communication method of contactless IC card system according to claim 4, further comprising the step of counting contactless IC cards entering the communication area within a predetermined time period, and wherein number of returning timings for a response block containing an ID code is determined in said step of acquiring ID code based on a count result the step of counting.

FIG. 1

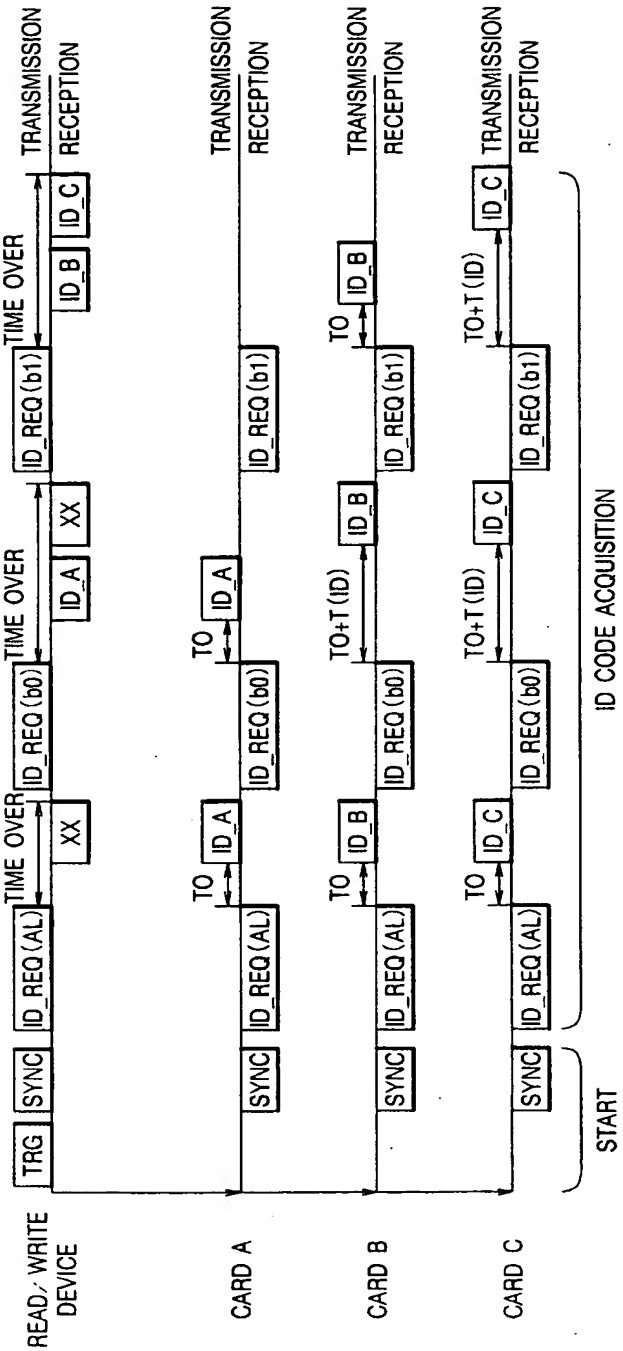

READ/WRITE DEVICE
CARD A
CARD B
CARD C
TRG
SYNC
ID_REQ (AL)
TIME OVER
XX
ID_REQ (b0)
ID_A
ID_REQ (b1)
ID_B
ID_C
TRANSMISSION
RECEPTION
TO
TO+T (ID)
START
ID CODE ACQUISITION
XX : DATA COLLISION

FIG. 2

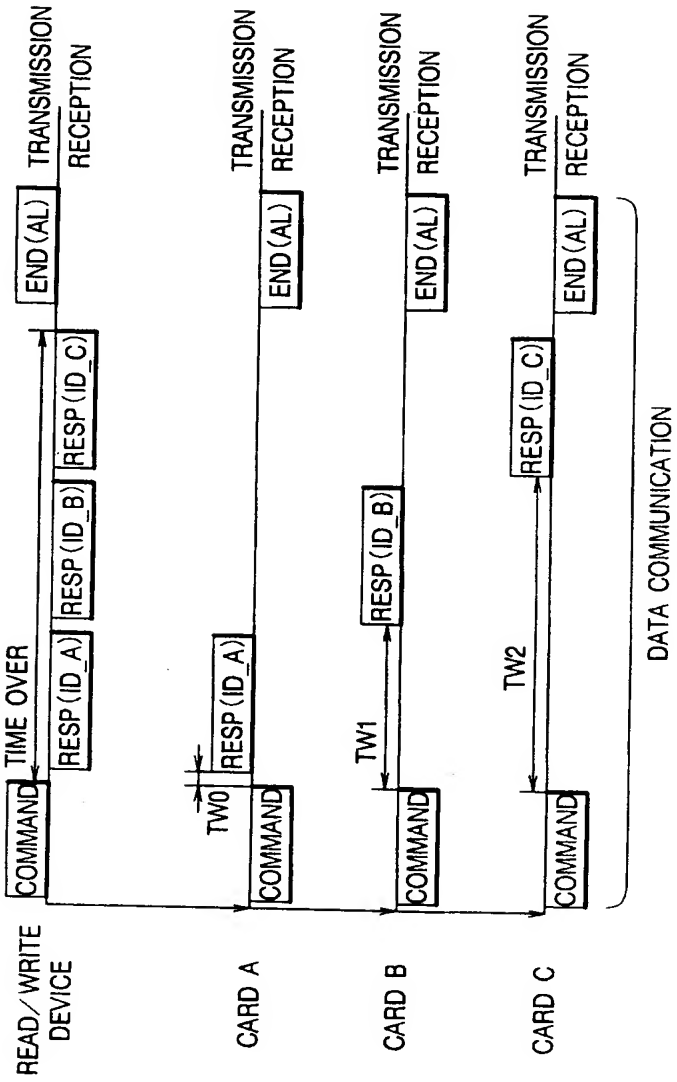

READ/WRITE DEVICE
CARD A
CARD B
CARD C
COMMAND
TIME OVER
RESP(ID_A)
RESP(ID_B)
RESP(ID_C)
END(AL)
TRANSMISSION
RECEPTION
TW0
TW1
TW2
DATA COMMUNICATION

FIG. 3A

ID_REQ(bn) BLOCK

STCR	LEN	ID_REQ	bn	CND1	TOF1	CND2	TOF2	• • •	ECC

FIG. 3B

COMMAND BLOCK-A

STCR	LEN	COM1	ID_X1	TW1	PAR1	COM2	ID_X2	TW2	PAR2	• • •	ECC

FIG. 3C

COMMAND BLOCK-B

STCR	LEN	COM	ID_X1	ID_X2	• • •	PAR	TW	ECC

FIG. 4

RESP(ID_X) BLOCK

STCR	LEN	ID_X	RESP	ECC

FIG. 5

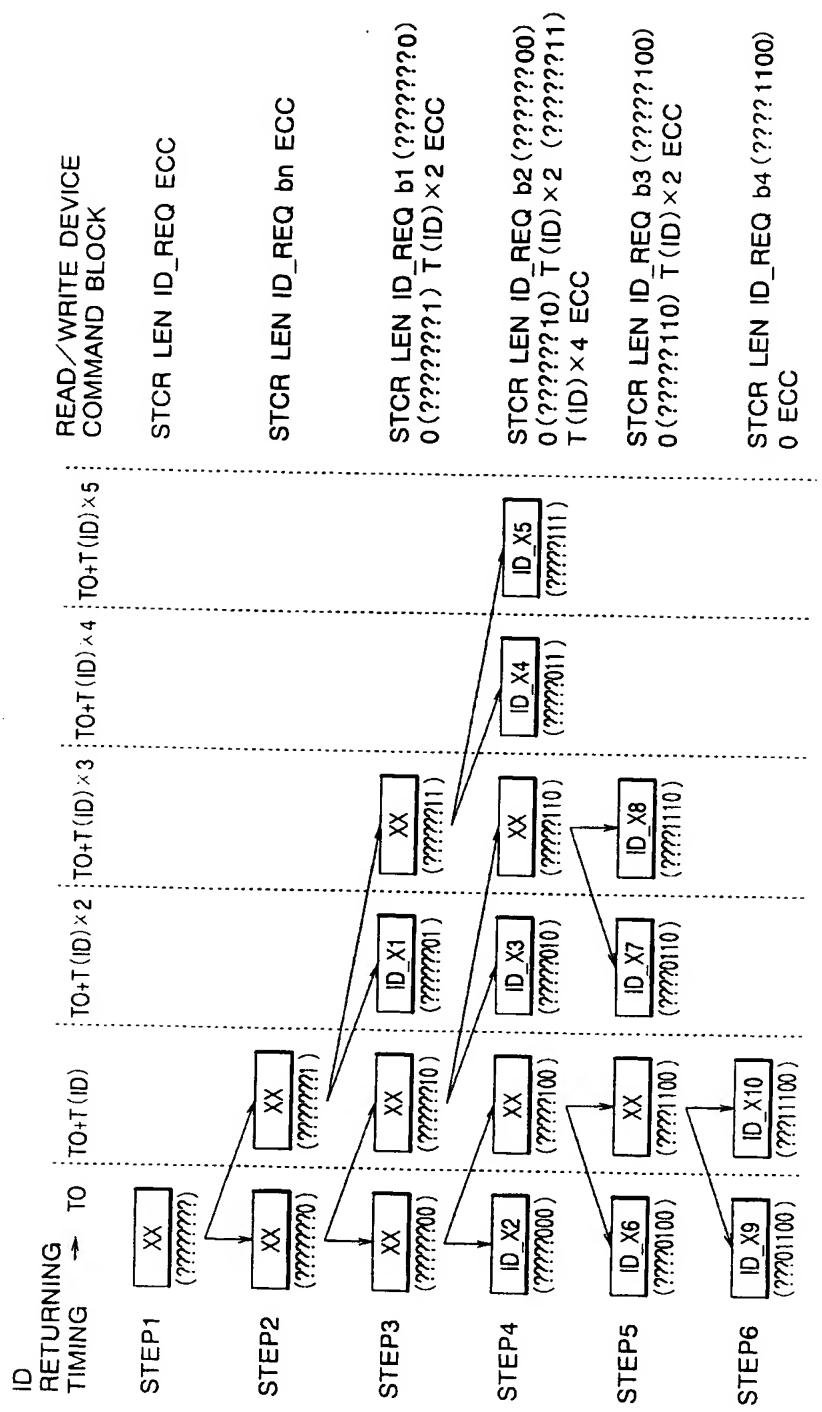
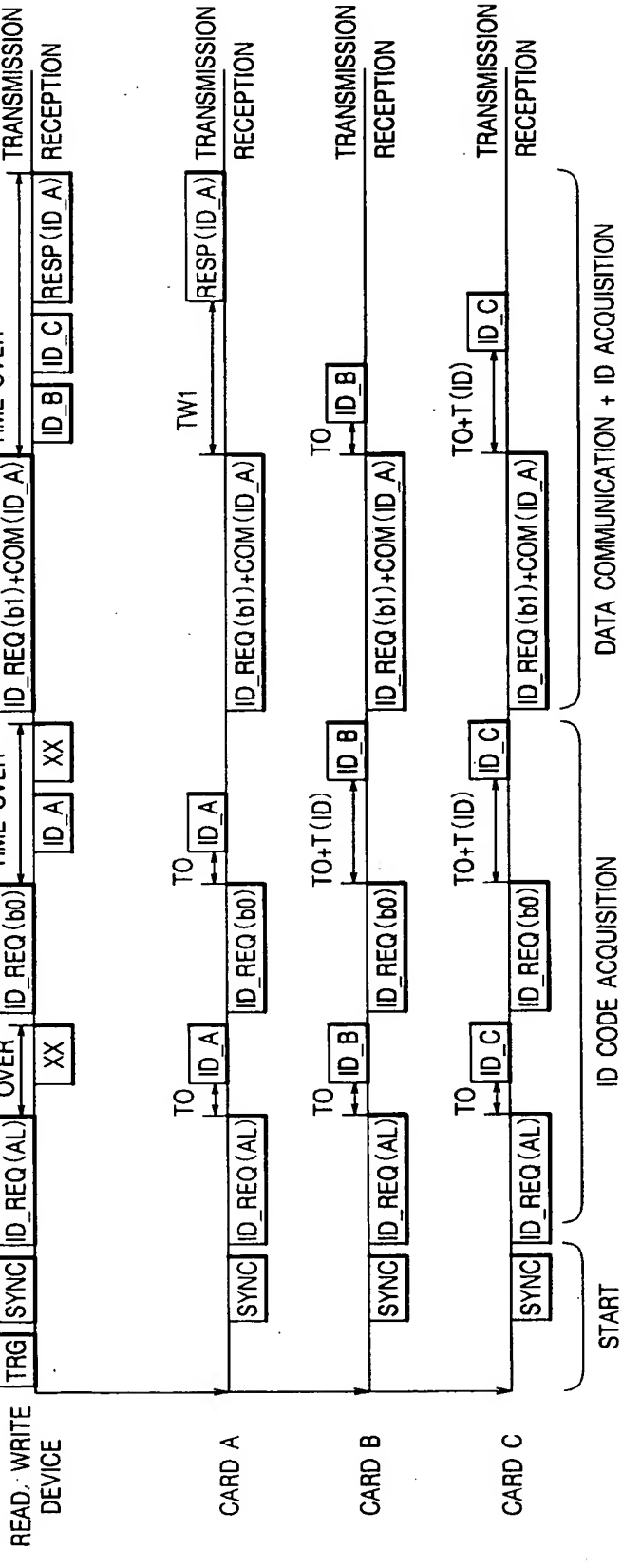

ID RETURNING TIMING → TO
TO+T(ID)
TO+T(ID)×2
TO+T(ID)×3
TO+T(ID)×4
TO+T(ID)×5
READ/WRITE DEVICE COMMAND BLOCK
STCR LEN ID_REQ ECC
STCR LEN ID_REQ bn ECC
STCR LEN ID_REQ b1 (????????) 0 (????????1) T(ID)×2 ECC
STCR LEN ID_REQ b2 (????????) 0 (????????10) T(ID)×2 (????????11) T(ID)×4 ECC
STCR LEN ID_REQ b3 (????????) 0 (????????110) T(ID)×2 ECC
STCR LEN ID_REQ b4 (????????) 0 ECC
STEP1
STEP2
STEP3
STEP4
STEP5
STEP6
XX (????????)
XX (????????0)
XX (????????1)
XX (????????00)
XX (????????10)
XX (????????01)
XX (????????100)
XX (????????110)
XX (????????11)
ID_X2 (????????000)
ID_X3 (????????010)
ID_X1 (????????001)
ID_X6 (????????100)
ID_X7 (????????110)
ID_X4 (????????011)
ID_X9 (????????100)
ID_X10 (????????100)
ID_X8 (????????110)
ID_X5 (????????111)

FIG. 6



XX : DATA COLLISION

FIG. 7

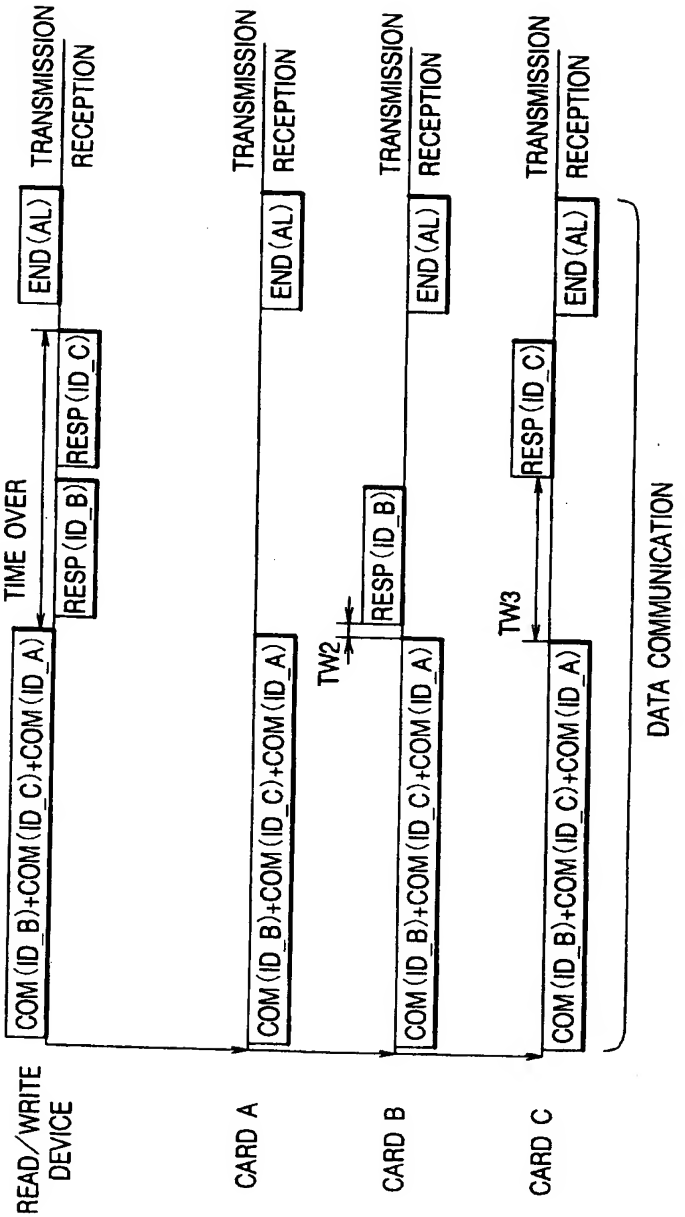

READ/WRITE DEVICE
CARD A
CARD B
CARD C
TRANSMISSION
RECEPTION
COM (ID_B)+COM (ID_C)+COM (ID_A)
END (AL)
TIME OVER
RESP (ID_B)
RESP (ID_C)
TW2
TW3
DATA COMMUNICATION

FIG. 8

ID_REQ (bn)+COM (ID_X) BLOCK

STCR	LEN	ID_REQ	bn	CND1	TOF1	•••	COM1	ID_X1	TW1	PAR1	•••	ECC

FIG. 9

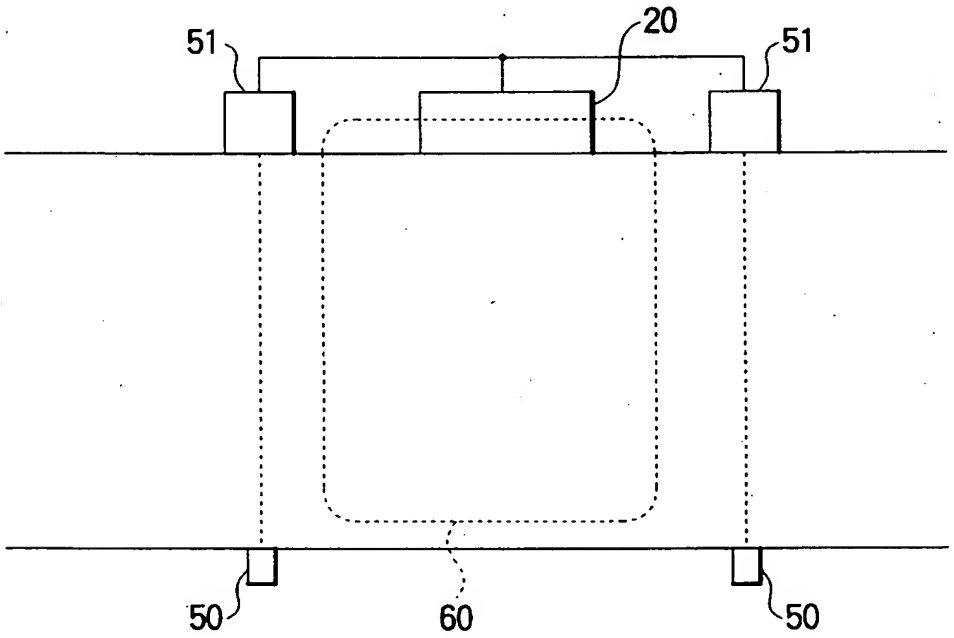


FIG. 10

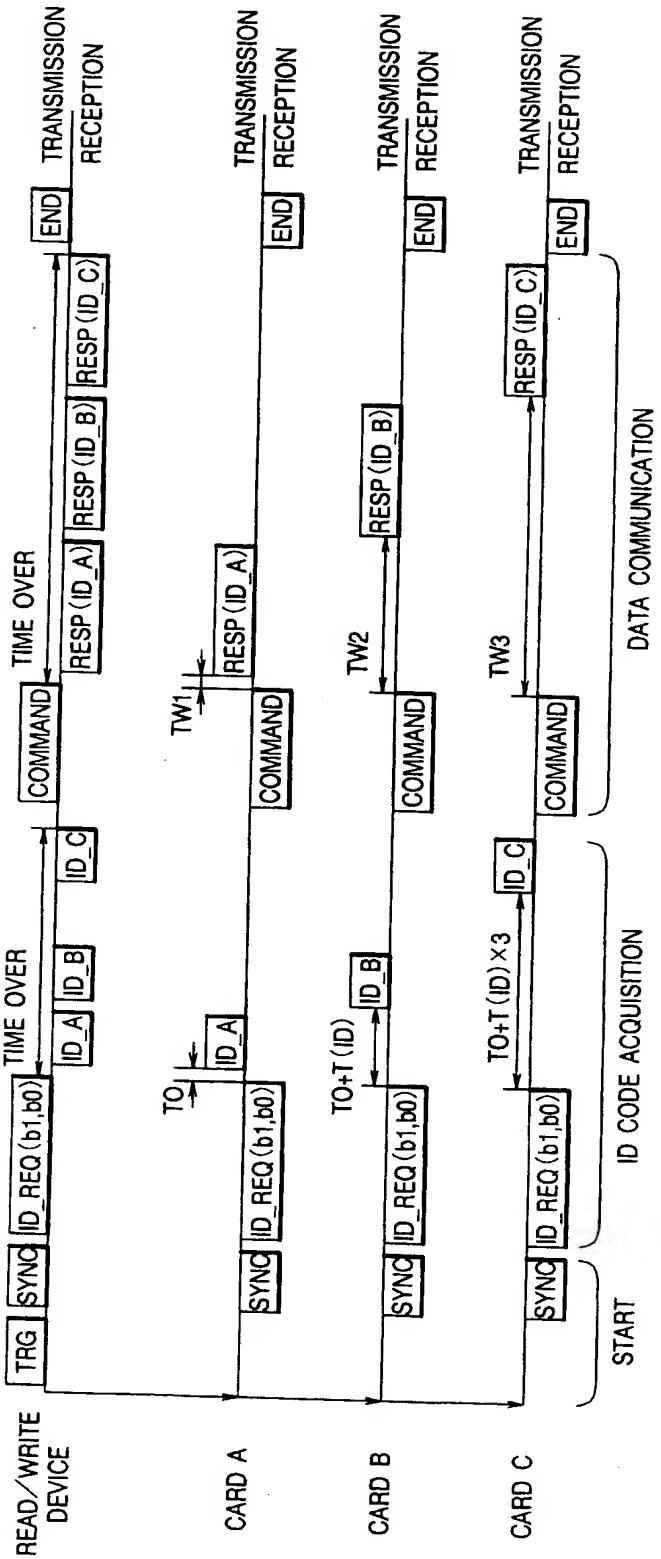
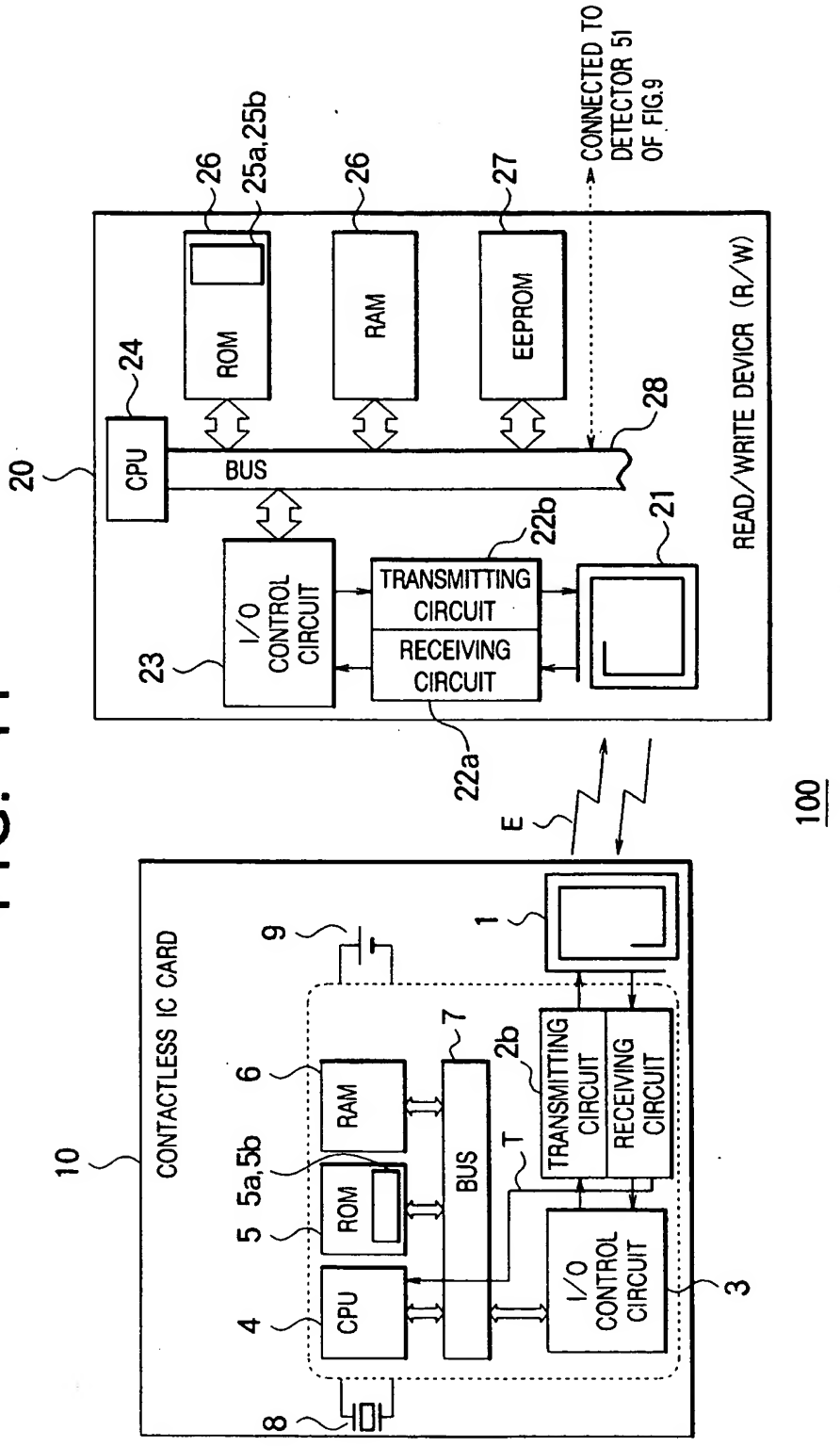

READ/WRITE DEVICE
CARD A
CARD B
CARD C
TRG
SYNC
ID_REQ (b1,b0)
TIME OVER
ID_A
ID_B
ID_C
COMMAND
RESP (ID_A)
RESP (ID_B)
RESP (ID_C)
END
TRANSMISSION
RECEPTION
TO
TW1
TO+T (ID)
TW2
TO+T (ID) ×3
TW3
START
ID CODE ACQUISITION
DATA COMMUNICATION

FIG. 11


CONNECTED TO DETECTOR 51 OF FIG.9
26
25a,25b
26
27
ROM
RAM
EEPROM
24
28
20
CPU
BUS
21
22b
TRANSMITTING CIRCUIT
RECEIVING CIRCUIT
I/O CONTROL CIRCUIT
23
READ/WRITE DEVICR (R/W)
22a
E
100
CONTACTLESS IC CARD
10
9
1
7
2b
6
RAM
5a,5b
ROM
5
4
CPU
BUS
T
TRANSMITTING CIRCUIT
RECEIVING CIRCUIT
I/O CONTROL CIRCUIT
3
8

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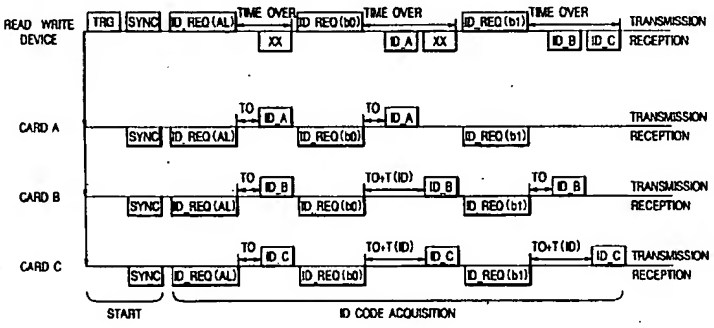
(54) Contactless IC card system and communication method thereof

(57) Even when a plurality of cards have entered an communication area, the cards within the communication area may be accessible, and, if a data collision occurs, the order of accessing to the cards is expeditiously determined to perform an efficient communication. Each card determines a timing for returning a response block containing an ID code based on conditions directed by a read/write device and the ID code of its own. The read/write device is caused to receive the response block returned by the contactless IC card and to detect a data collision. Based on this result, the conditions are changed so that a respective response block containing an ID code is returned again, thereby concurrently processing the plurality of contactless IC cards.

FIG. 1



XX : DATA COLLISION

EP 0 709 803 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 11 5710

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 5 266 925 A (L. C. VERCELLOTTI ET AL.) * column 2, line 56 - column 3, line 22; figures 1-4 *	1,2,4,5	G06K17/00 G06K7/10
Y	---	3,6	
Y	EP 0 494 114 A (CSIR SCIENTIA) * column 4, line 55 - column 5, line 46; figure 5 *	3,6	
A	---	1,2,4,5	
X	EP 0 495 708 A (GEMPLUS CARD INTERNATIONAL) * column 6, line 19 - column 9, line 3 *	1,4	
P,X	--- GB 2 283 600 A (NIPPONDENSO CO LTD) * page 9, line 26 - page 12, line 8; figure 2 *	1,2,4,5	
A	--- GB 2 259 227 A (GEC-MARCONI LIMITED) * page 17, paragraph 2; figure 2B *	1,4	
A	--- EP 0 427 342 A (N. V. PHILIPS' GLOEILAMPENFABRIEKEN) * column 6, line 1 - column 7, line 10; figure 3 *	1,4	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G06K
A	--- EP 0 161 779 A (SENELCO LIMITED) * abstract; claim 1 *	1,4	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	1 April 1997	Ducreau, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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